Title: Rotational Symmetry
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Math 7

Main Objective(s) of the lesson: Students will be able to recognize and describe rotational symmetry.
Students will explore properties of rotational symmetry - congruence and orientation.
Students will explore the concept of angle rotation. If a figure has rotational symmetry, there is a smallest angle of rotation, with all other angles of rotation being multiples of that smallest angle.

Foci for observation: What is the mathematical language of the students?
How do the students use the protractor and transparencies to identify rotational symmetry?
How do the students use the protractor and transparencies to identify angles of rotation?
How does the use of the Smartboard support students' ability to explain their discoveries?
How do the students transition from measurement to calculation – mathematizing the problem?

Background: Since we have begun our "Mathematical Road Trip", I thought it would be interesting to start students exploring the concept of rotational symmetry through hubcaps. The context will be that we are stuck in traffic after recently passing an old windmill and wagon wheel.

Students will be grouped in heterogeneous groups.
The Launch will ask students for individual responses, followed by a whole class discussion.
The Explore will be pairs, followed by group work.
The Summary will be a whole class discussion.

Lesson Phases	Plan	Resources Used	Anticipated Student Thinking	Possible Responses to Anticipated Thinking
Preparation	In a Flashback section of a recent homework assignment, be sure to activate the following concept and skills: - finding the center of a circle/regular polygon - using a protractor – extending lines			

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	to measure the angles with a larger protractor - finding ¼ of 360° Materials : Smartboard lesson Protractors / rulers Highway Hubcap Hunt handout Highway Hubcap Hunt transparency pieces	*Kaleidoscopes, Hubcaps, and Mirrors* Connected Mathematics *Navigating Through Geometry in Grades 6–8* NCTM		
Launch	As students enter the class, they will see a picture that will include a windmill, a quilt, an old wagon wheel, a butterfly, a reflection in a pond... They will be asked "Which of the objects could be grouped together? Explain your reasoning." Discuss how the windmill and the wheel are similar. These objects have rotational symmetry. Ask students what they think this means? Students may use the Smartboard to support answers. How often in a complete rotation do you think that each object will look the same? Can you think of other objects that have rotational symmetry? Discuss that the steering wheel can be rotated 120,240, or 360 about its center point and continues to look the same as the original. Model how it is found using a ruler and protractor. Define the angle of rotation to be the smallest angle a design can be rotated to coincide (match up) with the original design. Ask students "What is the angle of rotation for	Smartboard include double images of windmill, wagon wheel, butterfly, quilt, pond to show rotations vs. non-rotations Steering wheel	Students may group objects in categories such as "living vs. non-living", "plants, animals, and landmarks", "living things, structures, cloth" Some of the students may group objects together that have symmetry, but may not be able to differentiate between reflections and rotations. Once students hear the word 'rotate", they may respond that you can turn the object a little bit so that it looks like it did when you started. Students may count the starting position twice (once as the start and then again at the end.)	Walk around and listen-in on student thinking. Listen for words such as "moving", "turning", "shapes". *Have students clarify what "this" means so that they develop the appropriate mathematical vocabulary and refine their thinking. Use student's groups to subdivide images even further based on how they are symmetric (rotations vs. reflections) Use terms such as less than a full turn, centerpoint, original position.

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	the steering wheel?”		Initially, students may not realize that there is only *one* angle of rotation for the figure.	Refer back to the definition and highlight that it is the *smallest* angle of rotation.
Explore	Once we get back on the highway, we find that we are stuck in traffic. Let’s play a game using the concept of rotational symmetry! Let’s look at some of the hubcaps on the cars we see in traffic. Each student will be given 5 pictures of hubcaps – 4 will have rotational symmetry and 1 will not. With a partner, you will decide which hubcaps have rotational symmetry. If a hubcap *does not* have rotational symmetry, explain why. If a hubcap *does* have rotational symmetry, you and your partner will need to 1. Count the number of rotations before being back at the original figure. 2. Find the angle of rotation. Record your results in the table provided. Describe any interesting findings. Can you find the angle of rotation without measuring? Discuss your findings with the other pair of students in your group. Your group should agree to the same set of results.	Smartboard – images of hubcaps and duplicate image to rotate. Pictures of hubcaps. *www.jcwhitney.com* Set of transparencies of the hubcaps for each pair of students. There will be a mark outside each hubcap to help record the number of turns. The centerpoint of each hubcap will also be identified. rulers protractors recording sheets	Students may have a difficult time realizing that the bolts can cause a hubcap not to have rotational symmetry.	Use the Smartboard images to represent this during the summary.
Summarize	Each group will share their findings and methods. They may use the Smartboard images to support their reasoning. Explore the relationship between the number of rotations and the angle of rotations. If a figure has an angle of rotation of 360°	Smartboard.	Some students may not see a connection.	Ask students about the shape of the hubcap. What do they know about circles and angles? How can you use the fact that there are 360° in a circle with the number of turns to find the angle of rotation? How many angles of rotation does it take to add up to 360°?

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	does it possess rotational symmetry? Why do you think many rotating objects are designed to have rotational symmetry? Show the students a pinwheel and an image of the pinwheel. Ask the students if they can *apply* what they have learned to the pinwheel. "Does the pinwheel have rotational symmetry?" "How many rotations are needed before the image is back to the original figure?" "What is the smallest angle of rotation?" "Can you find the angles of rotation without using a protractor?"	Pinwheel (real one and image on the Smartboard.	Students may not think of functional reasons such as balance, efficiency.	Discuss the windmill - staying balanced and moving the air.

Appendices:

Extension – Apply the concepts to regular polygons. Find the number of rotations to make a complete rotation. Find the angle of rotation. What do you notice?

Students will be able to apply concept of angle rotation to rotating figures about a point *outside* of the figure. Eventually, this concept will be applied to the coordinate plane where students will analyze how the coordinates change under different angles of rotation. (Day 2 and possibly Day 3)